

Structured Decision Aiding Methods to Evaluate Environmental Management Options

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OUTLINE

1. Components of a structured process for understanding and evaluating environmental choices
2. Multi-attribute decision aiding techniques for improving environmental evaluations: policy, process, outcomes
3. Examples of structured deliberative processes in the US and in Canada and implications for the evaluation of ecosystem services.

A new context exists for conduct of environmental evaluations: Combining analysis and deliberation

- Idea is to broaden dialogue about environmental policy choices, also increase understanding and acceptance of options, by including input from multiple stakeholders.
- Enthusiasm not yet matched by knowledge or experience, so there is controversy: what methods to adapt, who to include, how to interpret findings, purpose (decision-aid vs. decision-maker).

*When do we know that an evaluation is
“good enough?”*

What do we want a “good enough” evaluation method to achieve?

Help people to understand the options

- Completeness: what matters in this context to those whose opinions should count?
- Comprehension: faced with novel options, what cues are used to understand choices?

Help people to evaluate the options

- Cognitively compatible: translate from people mind's to desired response mode
- Cognitively tractable: what details are significant? How much complexity is needed?
- Emotionally stabilizing: Incorporate emotional and affective responses
- Appropriately informative: Match precision of response to needs of decision makers

Need to ask: What is the purpose of the evaluation?

To support a benefit cost analysis:

monetary measure of benefits
(stated preference, CVM, hedonic)

To meet a regulatory standard:

technical information (threshold)

To satisfy a legal need for consultation:

town-meetings, perfunctory OK

To provide insight to decision makers:

create options, understand
reasons for support and/or
opposition

*Need to consider purpose before
selecting approach: sometimes one
approach is best, sometimes another!*

Decision-aiding methods ask:

- What is / are the decision(s) to be made?”
- “What matters? What are the objectives?”
- “What are the alternatives?”
- “What are the expected impacts of the alternatives, in light of uncertainty?”
- What are the key tradeoffs?
- “What alternatives can you support?”

These are the “primitives” of decision making and of evaluation. E.g., as the alternatives change, so does our wtp or our idea of a “good” outcome.

Origins of decision-aiding methods:

- Behavioral decision theory: how do people make choices? (Kahneman, Tversky, Slovic, Payne)
- Multiattribute utility theory(MAUT) & decision analysis (Raiffa, Keeney, vonWinterfeldt)
- Decision making under uncertainty (Clemen, Winkler, Morgan)

Key assumptions:

1) Use of a structured decision approach

(*Smart Choices*: Hammond, Keeney, Raiffa, 1999)

- Pr - What is the *problem*
- O - What are the *objectives*
- A - What are the *alternatives*
- C - What are the anticipated
consequences
- T - What are the key *tradeoffs*

2) Recognition of Constructed Preferences

Values and tradeoffs for many types of choices are not pre-existing but instead are formed in relation to context and problem framing.

3) Explicit consideration of uncertainty:

What is known (with what confidence), what is not known, & what is the value of new information?

Perspective of Constructed Preferences

For many important, complex, and unfamiliar environmental decisions, preferences and preference orders may be partially formed or non-existent and, as a result, need to be constructed on the basis of the elicitation context and cues. Constructed preferences are highly contingent preferences -- contingent on response mode, framing, reference points, task complexity, time pressure, and other contextual factors.

The valuation approach must function as a kind of tutorial, building understanding of the value as it elicits it. Analysts are architects, not archaeologists.

So if people look to contextual cues to construct values, then the objective of the decision-making process is to provide the best possible context for

- understanding the problem, and then
- evaluating the options

STEPS IN IMPLEMENTING A STRUCTURED, DECISION-AIDING EVALUATION APPROACH

1. Identify Stakeholders: Whose voice counts?
2. Define problem: identify constraints, distinguish fundamental objectives from means
3. Select Attributes: Develop measures of success in achieving objectives
4. Present alternatives so as to enhance evaluability and comprehension
5. Identify consequences, paying attention to different knowledge sources (e..g, TEK)
6. Clarify uncertainty: work with experts to identify anticipated range of impacts
7. Conduct tradeoff analysis: work with stakeholders to evaluate options and to identify reasons for and strength of support (or opposition/reluctance)
8. Learn and iterate

Case studies of decision-aiding processes for evaluating environmental services & policy options

1. Representative group: Alouette River
Hydroelectric Dam Relicensing
- 2) Community Participation: Tillamook,
Oregon: National Estuary Program
- 3) Expert Committee: Restoration of
Fisheries Habitat in Snohomish
County, WA
- 4) Citizen Committee: Options for off-shore
Oil and Gas exploration, Alaska
- 5) Citizen Committee: Adaptive mgt for
fisheries, Bridge River, BC
- 6) Interest representatives: Evaluation of
development options, Sabah, Malaysia

IDENTIFYING STAKEHOLDERS

USE OF TERMS

Stakeholders

Concerned Parties

Interests

IDENTIFYING AND PRIORITIZING OBJECTIVES

Representative sample
(survey)

vs.

Sample of representatives
(stakeholder committee)

Choice depends on

- (a) Complexity & significance of problem
- (b) Needs of decision maker(s)
- (c) Problem context (history and affect)
- (d) Resources: time, money

Define Problem: OPERATIONALIZING A STRUCTURED DECISION PROCESS

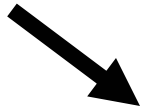
- Obtain agreement to using the group's time to bound and define problem (what matters, in this context, in light of the evaluation mandate)
- Create “objectives by alternatives” matrices for clarifying consequences of each major decision addressed by the individual or group

		Alternatives		
		A	B	C
Objectives	1			
	2			
	3			
	4			

Define Problem: LINK MEANS AND ENDS OBJECTIVES (important for identifying alternatives)

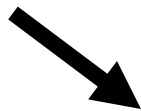
Ask WHY: Why is this objective important in the decision context?

- The objective is one of the essential reasons for interest in the situation.



Fundamental Objective

- The objective is important because of its implications for some other objective.



Means Objective

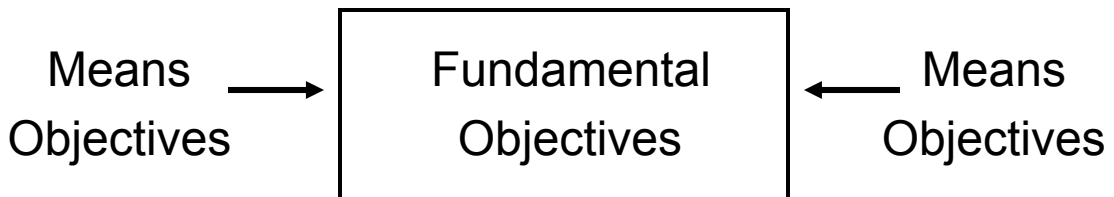
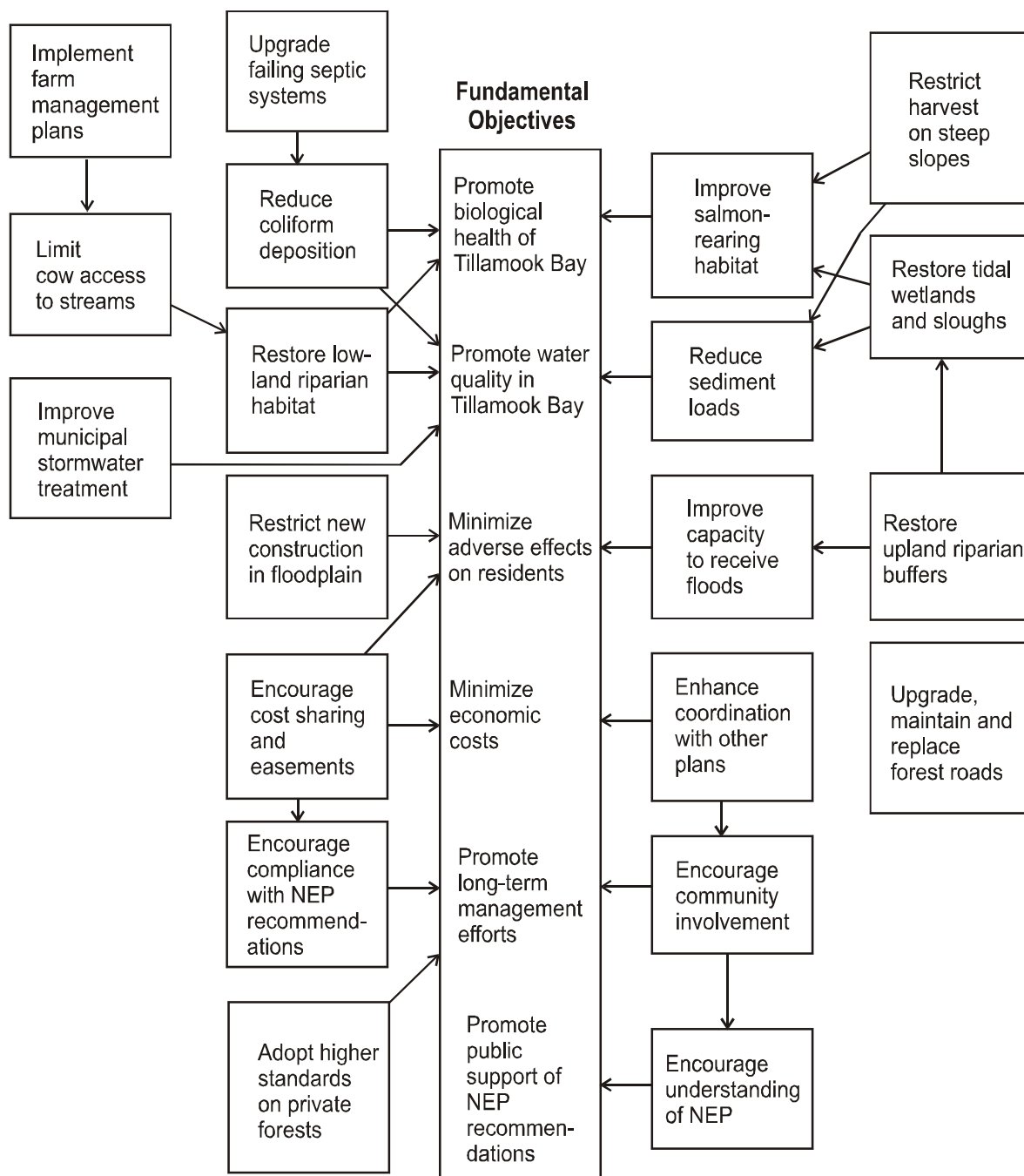


Figure 1: Tillamook Bay National Estuary Program (NEP) means-ends network



Note: The six fundamental (ends) objectives are shown in the center box. Means objectives, many of which became actions in the Tillamook Bay estuary plan, are shown at the sides. An arrow denotes "influences," between means objectives and from means to ends.

(Source: Gregory, 2000)

Select Attributes: Measures of Objectives

- Provide a way to identify progress in meeting objectives (“How good is this option?”)
- Provide a way to structure alternatives
- Provide a way to refine discussions of objectives
- Provide a way to select the preferred alternative(s)
- Provide a way to know what to value

Attributes: measure the degree to which the objectives are achieved

- Require both content & direction (what do we want?)
- Defined as a scale:
 - less ----- more
 - bad ----- good
 - few ----- many

Choice of measures

- Natural attributes (jobs, cost, acres)
- Constructed attributes (image, prestige, trust)
- Proxy attributes (nitrogen deposition, particulate emissions)

Source: R. Keeney & R. Gregory. Selecting attributes to measure the achievement of objectives. Operations Research 53: 1-11

Examples of constructed attributes

- **Biological impacts scale**

- 0 No loss of riparian areas along mainstream and at least 300 acres estuary restored
- 1 No loss of riparian areas and 100-200 acres estuary restored
- 2 No loss of riparian areas and no loss of estuary
- 3 Loss of not more than 100 acres riparian area and no more than 200 acres of estuary
- 4 Loss of > 300 acres riparian habitat and >500 acres estuary

- **Public attitudes scale**

- 2 Strong support: No groups are opposed to the facility and two groups or more have organized support
- 1 Support: No groups are opposed to the facility and at least one group has organized support
- 0 Neutrality: All groups are indifferent or uninterested
- 1 Controversy: One or more groups have organized opposition, although no actions are planned
- 2 Action-oriented opposition: At least one group has organized opposition, others are indifferent

Facilitates trade-offs: Is it worth \$10 M in added costs to reduce Biol impacts from 4 – 2? To increase Public support from –1 to +1?

Attributes for offshore oil/gas exploration, Cook Inlet, Alaska

Environment

Jobs

Health

- Industry Group

Compliance

Number

Worker

Whales & seals

Income

fatalities

- Environmental Group

Wildlife enhancement

Stability

Injuries

Species diversity

Type

Public
Illness

Clear communication not occurring due to imprecise definition of concerns!

Content result: wrong things are being evaluated

Process result: anger, frustration, deadlock

Source: U.S. Dept of Interior. 1992. Managing environmental risks: Minerals Management Service. Alaska OCS Region Study 92-0062. Washington, D.C.

Use of multiple attributes encourages participants to identify full range of concerns

- Scientific knowledge

generally given center stage; expert-driven, rules set by western science

- Traditional ecological knowledge

generally set off to the side. Can lose important objectives, observation-based insights, support

- Emotions

generally not considered helpful. Can lose important objectives (related to management, power issues), support, insights into new alternatives

- Trust (and other process concerns)

generally not treated explicitly. Not an art but open to analysis (e.g., an explicit “trust” objective), often masks other concerns & stalls progress (e.g., health is legitimate, mistrust of agency information is not).

Necessary to make sure that evaluation is comprehensive – if values are missing, then the evaluation of the problem is not complete.

Presentation of Alternatives

- Make consequences clear via attributes
- Present anticipated range of effects
 - needed for weighting of attribute importance
 - needed for focusing on management decision

Example: Bridge River consequence matrix

Objective	Performance Measure	Alt 4	Alt 5
Fish	Primary Productivity (tons carbon per year)	2600-4600	2400-4200
Electricity	Annual Revenue (\$/year)	+ \$510,000	- \$200,000
Cultural	Frequency of Access for Cultural Events	None	2 years in 10
	# site-days of exposure to illegal collection	510	320

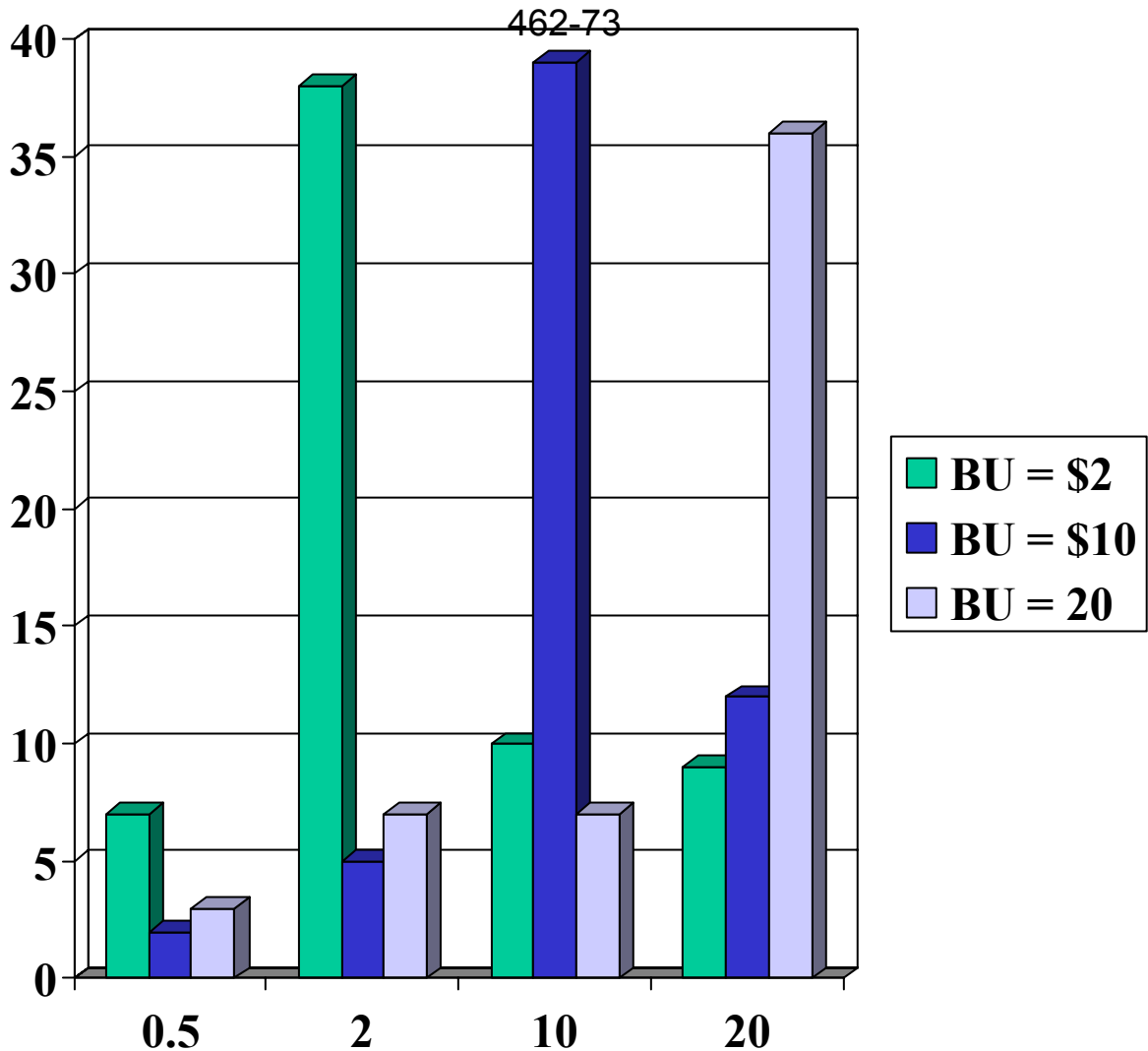
Focus on range of impacts rather than objectives per se can facilitate deliberation as well as learning – focuses resources, dialogue.

Source: L. Failing, R. Gregory, M. Harstone. Integrating Knowledge Sources in Environmental Management Decisions: A Practical Approach. Under editorial review.

Presentation of Alternatives: Fit precision of response metric to understanding of value

Example: Histograms of WTP responses, showing that a high percentage of respondents look to an arbitrary budgetary unit when valuing env'tal stimuli (habitat pres, roadside clearing, etc.)

Source: Gregory et al. 1995. How precise are monetary representations of environmental improvements? Land Economics 71:



Presentation of Alternatives

Comparisons are helpful: evaluation of options requires context for understanding

What does it mean to pay \$10 for an improvement?

What does it mean to be paid \$20 for a damage?

Separate vs joint evaluation

Consider two second-hand music dictionaries (Hsee)

	<i>Number of entries</i>	<i>Any defects?</i>
Dict. J	20,000	Cover torn, otherwise like new
Dict. S	10,000	No, it's like new

WTP for one dictionary:

Mean wtp for S = \$27

Mean wtp for J = \$20

WTP for both dictionaries:

Mean wtp for S = \$19

Mean wtp for J = \$24

In joint evaluation, with multiple alternatives, people can compare one option to the other. By comparing dimensions of value, difficult-to-evaluate attributes (#) become easier to consider.

MAUT: multiple options, decomposed, multiple metrics
(vs. CVM. single option, holistic, single \$ metric)

Example:

SMALL GROUP CONSULTATION

Alouette River, British Columbia

(with Tim McDaniels, 1996-97)

Multi-stakeholder committee of 20 representatives, charged with considering the pros and cons of alternative water flows and making recommendations to local utility.

Objectives:

- Avoid adverse effects from flooding
- Promote the ecological health (fish) of the Alouette River
- Avoid cost increases to residents of B.C.
- Promote recreational opportunities
- Promote flexibility and learning

15 Stakeholder Committee meetings, February - August, 1997

Agreement reached on all issues:

- flood control, fish flow releases, recreation
- power generation, adaptive management

What worked? Agreement on structured decision process

- agreement on evaluation rules and decision process
- recognition of shared objectives (yet different weights)
- emotional reactions permitted and incorporated
- recognition of uncertainty re. high-end fishery gains
- costs of “no agreement” perceived to be high
- fully representative committee, flexible client

Source: Gregory. McDaniels & Fields. 2001. Decision aiding, not dispute resolution. *Journal of Policy Analysis and Management* 20:415-432.

Presentation of alternatives: Alouette River, B.C.

Objective	Benefit	Cost	Recommend
Promote Ecological health	Flushing flow (substrate quality)	\$50-75K yr with preset timing	Reject (accept w/ flexible - \$2-30 K)
Improve water quantity	Better/ more fisheries habitat	\$270-440K yr	Adopt (to flow limit of facility)
Avoid flooding Effects	> Protect from 1-12 to 1-32	\$30k/yr	Adopt
Promote recreation	Improve angling opports	Minimal	Adopt
Avoid cost increases	Max fisheries potential	\$700K/yr + \$3-6 million capital	Reject
Promote learning & flexibility	Ongoing mgt comm + monitor	\$50k/yr	Adopt

Understanding consequences of options (what is being evaluated?)

Various tools available:

- Influence diagrams
- Decision trees
- Use different sources of knowledge:
 - expert (scientific)
 - traditional (Aboriginal)
 - local resource users
- Use different presentations: words, charts, maps, field trips, narratives

Example: Bridge River process (and influence diagram – next page)

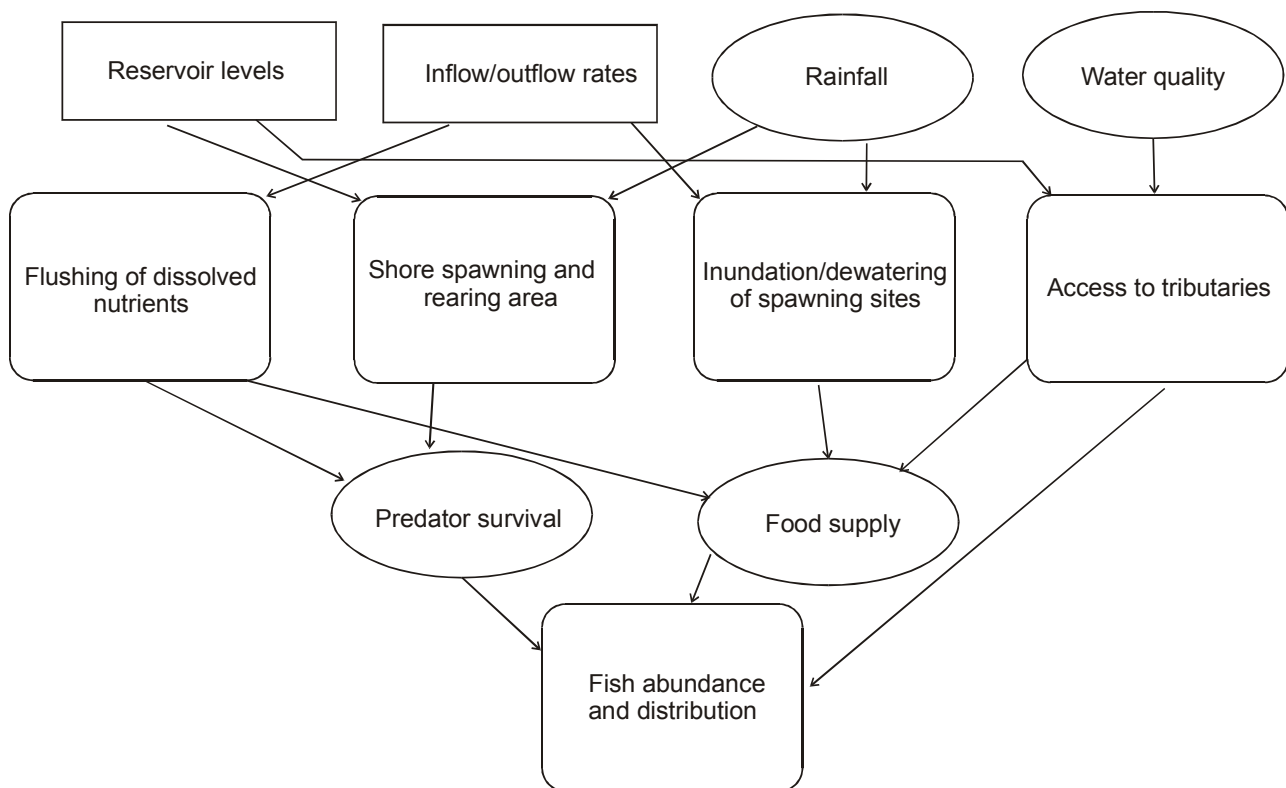


Figure 2. Influence diagram for fish response in hydroelectric facility relicensing. Rectangles represent decisions, ovals represent chance events, and a rectangle with rounded corners represents a consequence. Arrows (arcs) denote a relationship among the nodes.

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CLARIFY SCIENTIFIC UNCERTAINTY

What is the basis for the uncertainty?

- values-based uncertainty: what matters?
- facts-based uncertainty: what will happen?

Clarify range of scientific values and examine to understand reasons for disparity in perspectives

- different concerns or value weights
- different access to information
- different interpretation of same information

Use tools to encourage dialogue

- Influence diagrams
- problem decomposition (complex-simple)
- expert judgment elicitations: make full use of what is known, identify areas for further discussion/study
- value-of-information studies: to what extent would better information change management decisions?

Uncertainty: Use of formal expert judgment techniques

Formal processes should be used:

- articulate questions to answer
- train experts re judgmental biases
- decompose complex technical question
- elicit probability distributions
- recombine and aggregate across experts
- encourage dialogue and document

Reductions in uncertainty yield better defined alternatives, better evaluations

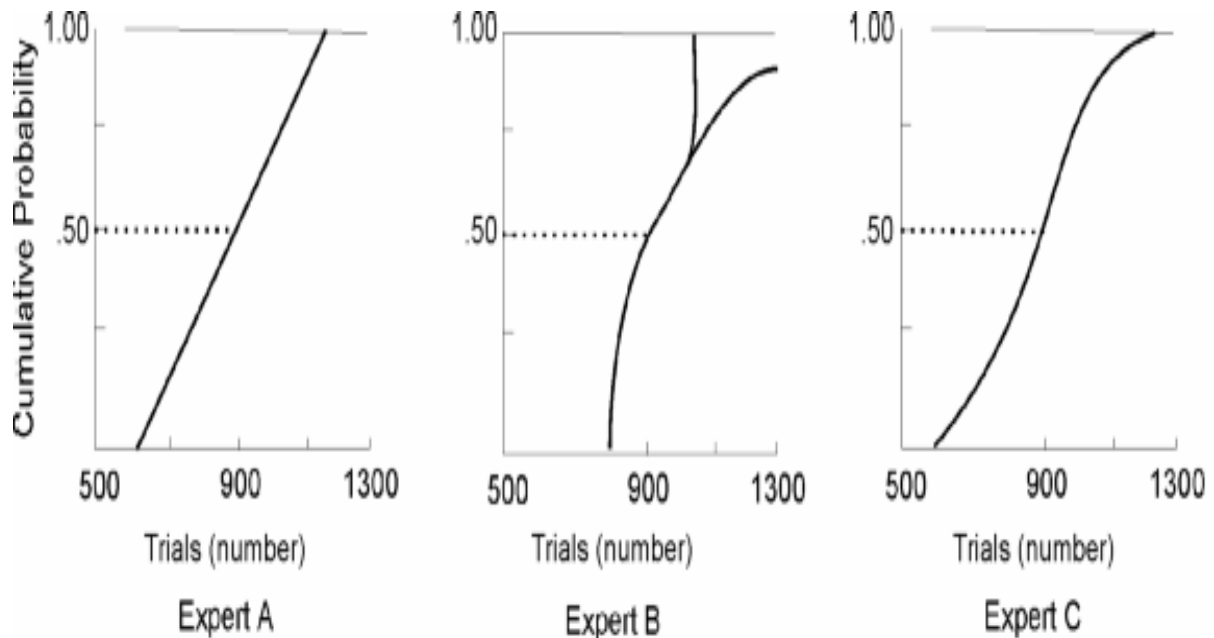


Figure 2. Example cumulative probability distributions from three experts for the question: How many additional trials will be needed to ensure product safety?

MAKING TRADEOFFS

Getting more of one thing of value almost always requires giving up something else of value, which means that explicit attention to tradeoffs is required.

One option is to weight alternatives (holistic)

Often better to weight component objectives:

- Pricing out: monetize, i.e. convert impacts into dollars
- Swing weights: assess relative importance of objectives

Look at range of impacts

Objective	Worst	Best	Rank	Rate
A (Env't)	600 H	100 H	_____	_____
B (Cost)	\$30 mill	\$7 mill	_____	_____
C (Empl)	-60 jobs	+45 jobs	_____	_____

Which impact would you most prefer to get rid of?
(i.e. to swing from worst to best?)

- Even swaps: simplify decision problem by eliminating dominated alternatives (ask: which objectives highlight differences in alternatives?). Increases ease of evaluation by focusing on key elements.

Tradeoffs example: Develop coal resources or preserve forest?

Example: Sabah, Malaysia EIS

- Initial framing: preserve tropical rainforest or develop thermal coal resources (A or B?).
- Elicit objectives for 5 stakeholder groups : environmental, economic, social, prestige, political
- Revisit alternatives: Preservation option requires funding (incremental losses), Coal development could be open-pit or underground. Also interest expressed in tourism, social development, etc.
- Create new alternatives:
 - Preservation with development
 - Preservation with tourism

Initial framing as A or B led to false TOs. Poorly structured problem. Reframing in terms of fundamental objectives led to new alts, also new studies (to clarify impacts, reduce uncertainties, etc). Use of consequence matrix helped evaluation.

Source: R. Gregory & R. Keeney. 1994. Creating Policy Alternatives Using Stakeholder Values. *Management Science* 40: 1035-1048.

Tradeoffs Example:

Tillamook Bay, Oregon

(National Estuary Program, 1997 - 2000)

Worked with EPA's National Estuary Program office to develop scientific and public input to CCMP

Provide a defensible set of alternative actions (showing benefits, costs, and support) to assist in estuary conservation. Which ones to recommend?

1. Organize actions into fundamental objectives of program

- promote biological health
- promote water quality (means)
- reduce economic costs
- encourage long-term learning
- promote implementation of recs.
- promote citizen participation

2. Understand scale and timing of actions

- Marginal benefits and costs
- Sequential timing
- Uncertainty

Source: R. Gregory & K. Wellman. Bringing stakeholder values into environmental policy choices. *Ecological Economics* 39: 37-52.

Tillamook Bay (EPA/NEP): Community Participation (p. 2)

3. Evaluation insight via value-integration survey

- Preferences: voting
- Preferences: willingness to pay

Example choice task (flowchart: if Plan A OK, how much Plan B? If Plan B too much, ...).

Question: % wtp \$3-5,000/acre for marg. land?

	Plan A (one-time)	Plan B (multi-yr)	Plan C ("better")
Benefits			
> Storage for floods	Low improve	Moderate improve	
> Salmon habitat	200 acres	750 acres	
Lower bay pollution	moderate	moderate	
Costs:			
Loss of access	low	low	
New tax payments	\$200K	\$2.2 million	

Learn and iterate

Technique: Adaptive management -- multiple trials to reduce uncertainty

Example: Snohomish estuary, Washington

Question: Agency (EPA, SS) wtp for AM vs. simply monitoring of restoration actions

Need explicit criteria:

Spatial scale, Dimensions of uncertainty, Magnitude of effects, Presence of external effects, Perceived costs of failure, Continuity of institutional support, Community support

Need explicit hypotheses re. benefits

Questions: What is the value of learning?

What is the benefit of lower uncertainty?

When is it worth spending \$/time to know more? (VOI, in terms of improved outcomes)

Need a decision frame that incorporates multiple dimensions and uncertainty as well as benefits and costs. Choice for Snohomish: MAUT, with economic analyses serving as input to overall (weighted criteria) evaluation of options.

Learn and Iterate:

Analysis + dialogue

1. Individuals learn about facts

- What participants want to know
- What participants should know (integration, surprises)
- Reducing uncertainty over time (feedback)

2. Individuals learn about themselves

- Values and emotions (in relation to others)
- Tradeoffs (in relation to conflicts & choices)
- Uncertainty (risk aversion, precautionary principle)

3. Individuals learn about each other and institutions

- survey results
- small-group discussions
- stories and informal dialogue

Learning as an explicit objective – how to formally incorporate learning over time?

What learning is needed, by whom? (values vs. facts)

How much learning is enough? (informed preferences)

What criteria exist for measuring learning, so that decisions are defensible? (informed consent)

Emphasis on decision insight leads to changes in allocations of time and resources

**Primary goal of evaluation: to provide information
that will help to yield a good decision**

- satisfies values
- technically correct
- logically defensible

Conventional

vs.

Decision-Aiding

Structure problem:
values, one option +/-

Structure problem
(values, measures,
tradeoff, alternatives)

Evaluate impacts:
single metric (\$)
single option

Evaluate impacts:
multiple metrics |
multiple options

Communicate & refine
evaluation

Communicate, learn,
iterate, & refine evaluation

Decision Aiding for Improved Analysis and Deliberation: What Can We Hope to Achieve?

- Represent problem as usefully as possible
- Achieve better, more explicit & open deliberations
- Make use of full knowledge base (community, TEK)
- Represent range of reasonable alternatives
- Represent tradeoffs explicitly: gains and losses
- Lead to a better structured debate, with opinions informed by knowledge of values, emotions, facts
- Build in learning over time (adaptive management, flexible consultation) and reduce uncertainty
- Encourage participants to work within process (I.e., reduce litigation and “behind the scenes” deals
- Improve linkages between analysis and deliberation

Summary: Lessons for evaluating environmental management options

- Evaluation requires initial decomposition & then subsequent integration across multiple dimensions of the problem.
- Evaluation is a means to an end – better decisions – which in turn is an means to satisfying preferences.
- People need to first understand the options (what matters, in this problem context) and then to evaluate them (understand the response mode, recognize what is important), within constraints.
- More interdisciplinary empirical studies are needed to identify meaningful criteria (such as above?) and to compare methods across these criteria.
- People "evaluate" all the time, using dollars, paired comparisons, utils, sweat, pain, etc. Evaluating environmental services & options is not as special a case as we tell ourselves – spread a wider net.
- Overall, analysts need to avoid disciplinary blinders, and be open to new ways to incorporate public values into environmental policy decisions.

"Now is my way clear, now is the meaning plain:

Temptation shall not come in this kind again.

The last temptation is the greatest treason:

To do the right deed for the wrong reason.

T.S. Eliot. *Murder in the Cathedral*